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An automatic vision system for analysis of microscopic behavior of flow and transport in porous media

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This paper describes the development of a novel automated and efficient vision system to obtain concentration and velocity measurements within a porous medium. An aqueous fluid laced with a fluorescent dye or micro spheres flows through a transparent, refractive-index-matched column packed with transparent crystals. For illumination purposes, a planar sheet of laser passes through the column as a CCD camera records all the laser illuminated planes. Detailed microscopic velocity and concentration fields have been computed within a 3D volume of the column.

For measuring velocity, while the aqueous fluid, laced with fluorescent micro spheres, flows through the transparent medium, A CCD camera records the motions of the fluorescing particles on video cassette recorder. The recorded images are acquired automatically frame by frame and transfer to the computer for processing, by using a frame grabber and written relevant algorithms through an RS-232 interface. Since the grabbed image is poor in this stage, some preprocessing will be used to enhance particles within images. Finally, these enhanced particles will be monitored to calculate velocity vectors in the plane of the beam. At the end, the pore-scale velocities and the average properties of the measured velocity field are discussed and are shown to be in agreement with the overall averaged theoretical velocity.

For concentration measurements, while the aqueous fluid, laced with fluorescent dye, flows through the transparent medium, a CCD camera sweeps back and forth across the column and records concentration observations on the planes illuminated by the laser beam traveling simultaneously with the camera. Subsequently these recorded images transfer to computer for processing in similar fashion to the velocity measurement. In order to have a fully automatic vision system, several detailed image processing techniques are developed to match exact images that have different intensities values but for the same topological characteristic. This results in normalized interstitial chemical concentrations as a function of time within the porous column.

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